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High End Computing for National Security

Conclusions of an
Integrated Process Team

April 1997

1

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HPC IPT Tasks Addressed by this Report

- What are the alternative future scenarios with respect to the US international lead in the high end of high performance computing?
- What is the threat to national security associated with each scenario?
- What technology advantage is necessary for the US, if any?

2

DDR&E called for an Integrated Process Team (IPT) in April 1996. The IPT was assembled and initiated work in July 1996. The team collected needs, industry views, and reviewed market analyses. Based on the information collected, the IPT developed its conclusions. The IPT consisted of members from DARPA, NSA, DOE, NASA, NRL, Air Force, Army, NCO, OSD, CIA, and HPMO and was chaired by the DARPA member.

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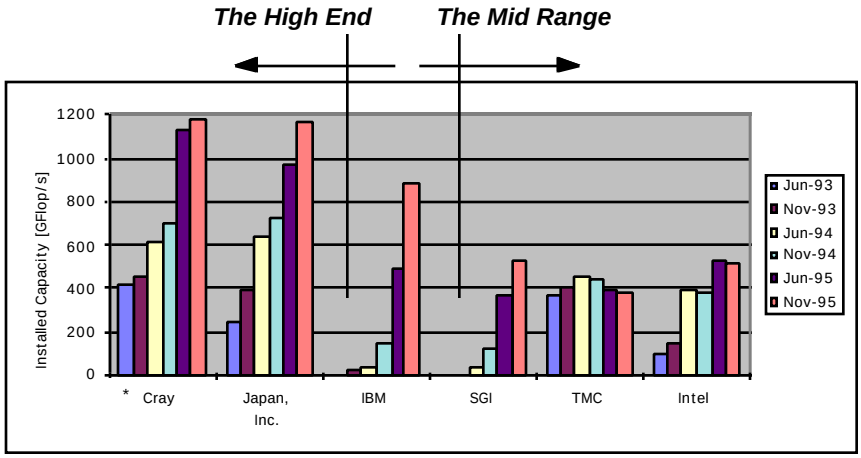
What Is High End Computing?

Manufacturer's Performance: A Moving Target



Source: Top 500 Supercomputer Sites compiled at Mannheim University
http://www.netlib.org/benchmark/top500

* Now SGI/Cray

3

The high end is a moving target. Some define it as the capabilities of the top 50 machines in the world. Here is a picture of the installed computational power of the largest facilities in the world. In 1996, TMC and Intel were no longer producing commercial machines.

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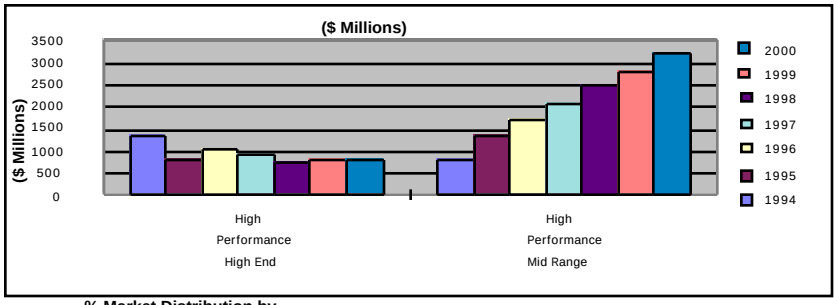
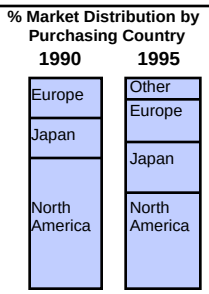
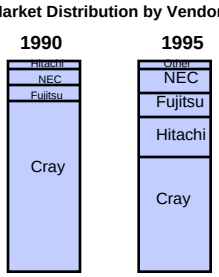
High End Market Flat; Strong Growth in the Mid-Range



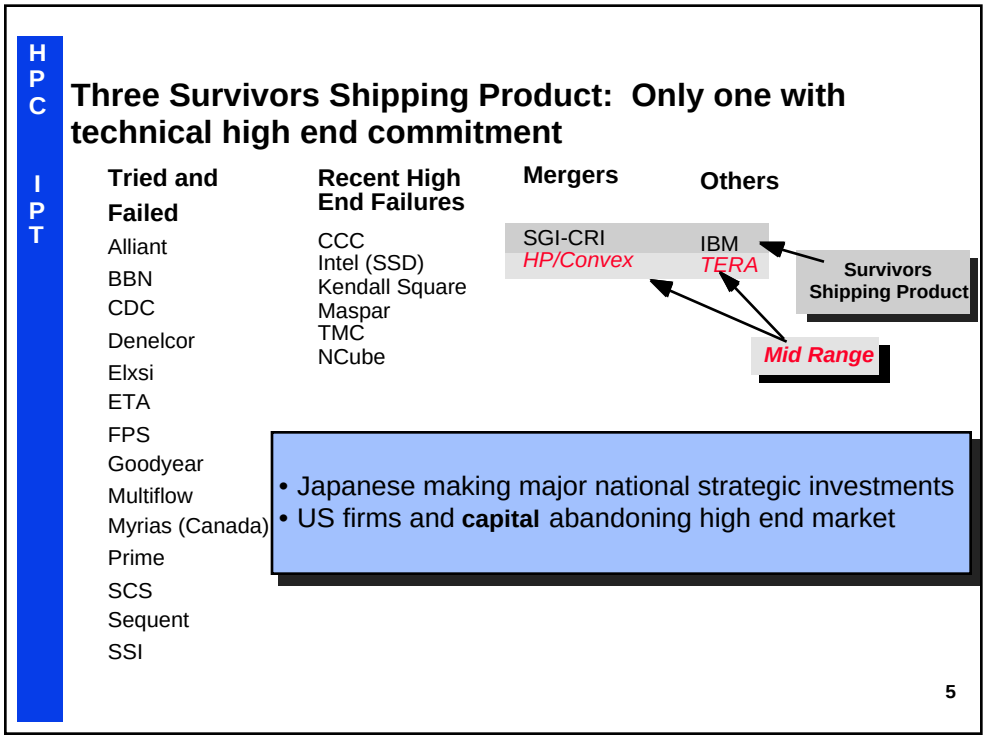




Source: International Data Corporation, 1995

4

Many US companies abandoned the high end because of flat/declining market with insufficient ROI for future investments, aggressive competition and the potential for higher returns in the mid range.



Worldwide revenues are down 30% from 1994. Numerous companies failed in the market with high end losses by the remaining providers. There are only two US companies shipping high end computers today: SGI/Cray which supplies systems with direct applicability to national security problems and IBM which ships principally to the business market but which is providing a system to DOE's ASCI program. HP/Convex produces mid-range systems. Tera is a start-up which has not yet shipped a commercial system. Japanese companies have embarked on an aggressive investment program supported by vigorous Japanese government procurements at a number of universities.

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Federal Investments Fueled Today's US Technology Success

6

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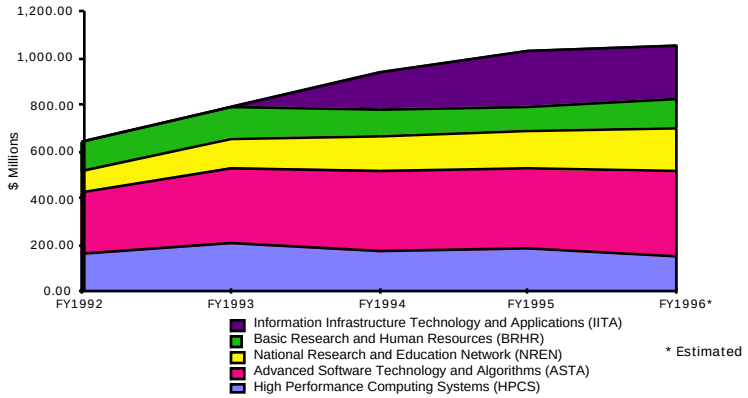
Estimated Overall Federal High Performance Computing and Communications Program Expenditures by Components

	FY1992	FY1993	FY1994	FY1995	FY1996
HPCS	156.80	205.50	171.20	177.90	146.70
ASTA	265.10	325.90	352.10	350.30	371.00
NREN	91.90	123.40	142.10	163.50	185.60
BRHR	124.50	140.40	116.50	106.30	128.10
IITA	0.00	0.00	156.00	240.00	228.20
Total	638.30	795.20	937.90	1,038.00	1,059.60



7

The Federal HPCC program was initiated in 1992. It has many activities including human centered systems, information infrastructure technology, networking and high end computing. The IPT estimates that HPCC investments applicable to the high-end of computing have fallen from a peak of approximately $230 million in 1995 to about $150 million in 1997. The IPT estimates that approximately one half of this amount ($75 million) is directly applicable to high end ***national security*** *needs.*

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Federal R&D High End Investments Fueled Today's Technology Successes

- Established scalable parallel processing as the commercial standard for high performance computing
- Enabled the technology base for the $2 billion middle range high performance market which expanded access to high performance computing while reducing costs to the government
- Invented and proved massively parallel systems as effective high end computing devices
- Enabled the near-term computing technology for DOE's ASCI program
- Created the scientific base for High End Computing including trained scientists and engineers, new architectural approaches and next generation technologies

8

The Federal Program produced significant technological successes. It did not address procurement and near-term prototyping issues. The emergence of mid-range processors enabled by Federal technology increased overall availability of powerful machines for the defense and national security, while reducing the cost of these systems to the average defense user. Partially because of the availability of this more attractive option for smaller scale problems, the very high end of the commercial market is now smaller and more specialized. Market growth in the middle proved to meet the needs of most commercial and government customers leaving a principally government high end market.

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National security policy-driven needs

US requires superiority in high end computing for:

- Superiority in weapons design
- Comprehensive test ban treaty
- Critical reaction capability/time for defense
- Battlespace dominance; revolution in military affairs

Superiority in critical defense technologies
requires
Superiority in high end computing technology.

9

It is the belief of the Integrated Process Team that superiority in critical defense technologies requires superiority in high end computing technologies. The US needs assured and timely access to these technologies.

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National Security Applications

- Nuclear weapons stockpile stewardship: Weapon effects simulation to extend stockpile in era of no new design
- Wide area imagery: Near real time analysis of imagery with 3D Resolution, 100,000 sq. mile coverage and high resolution
- Cryptology: Rapid decryption of multiple messages
- Vehicle and weapons design and test
  - High performance aircraft design and test: Full 3D multi-disciplinary (aero, structures, magnetics, propulsion, controls) simulation
  - Weapons systems such as high power RF weapons: End-to-end simulation to predict complex systems response to weapons effects
  - Target discrimination: Combat identification, signature extraction and rapid target insertion for advanced platforms

10

There are many national security applications which require high end capabilities.

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National Security Applications (con't)

- Intelligence data and information extraction
  - Remote sensing exploitation: Parameter analysis of chemical species and spectral band)
  - Chemical detection (FTIR remote sensor): Infrared image generation for radiometric, thermal and emissivity analyses
  - Intelligence data and Information extraction: Reduce time for analysis of complex sensor data from two weeks to real time
- Synthetic theater of war C^3: Mission rehearsal and decision support for Desert Storm size scenarios in faster than real time

11

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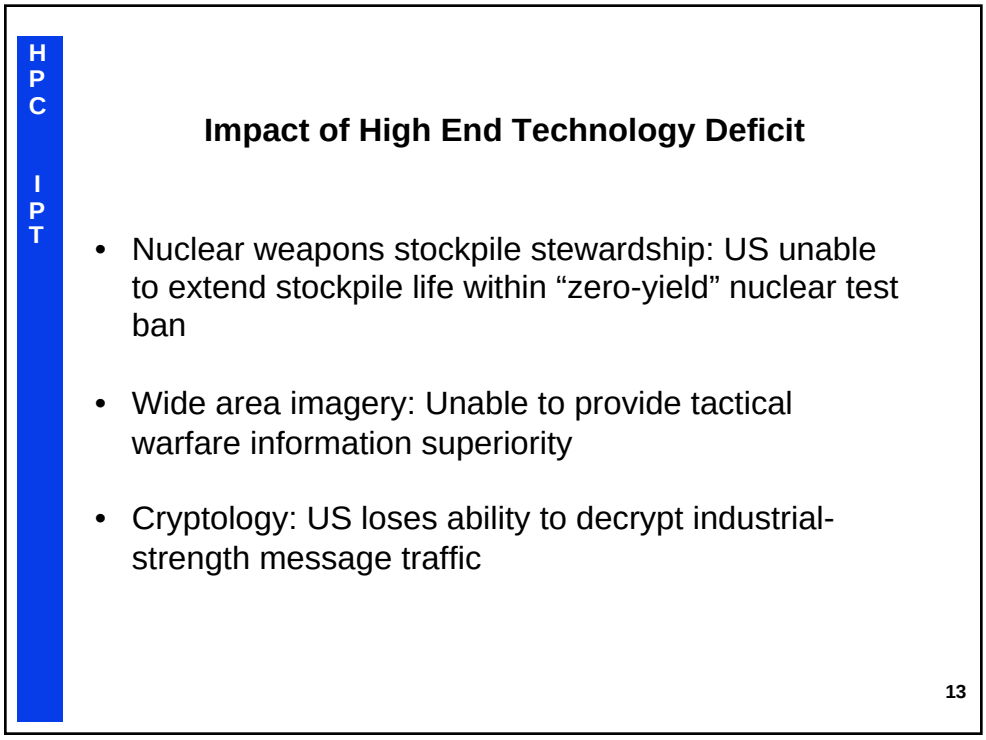
Computational Speedups of 1,000-1,000,000 required by 2010

- Nuclear weapons stockpile stewardship: 100,000 - 1,000,000X
- Wide area imagery: 2,000X
- Vehicle and weapons design and test
  - High performance aircraft design and test: 10,000-100,000X
  - Weapons systems such as high power RF weapons: 1,000+X
  - Target discrimination: 3,000
- Intelligence data and information extraction
  - Remote sensing exploitation: 10,000-100,000
  - Chemical detection (FTIR remote sensor): 300,000X
  - Intelligence data / Information extraction: 3,000X
- Synthetic theater of war C^3: 100,000X

12

National Security needs for high end computing exceed projections of commercial mid-range processing by factors of 10 to 10,000. Emerging defense applications will make even greater demands on the technology. According to industry suppliers, national security needs have been 10 to 100 times greater than the greatest needs of their commercial customers with trends continuing this disparity.



Some of the impacts of the high end technology deficit are listed here. DOE will not be able to have the computational base required to extend stockpile lives without testing. Real-time image analysis and target insertion in battle systems will not be possible. Modern cryptographic techniques will defeat attempts to decrypt traffic. Continued aircraft performance increases may be imperiled because of the inability to model complete vehicles and weapons. We will be unable to predict weapons effects for weapons systems such as high power RF weapons. Real time insertion for target discrimination will remain out of reach. We will be unable to utilize advanced sensor capabilities to predict atmospheric effects and our adversaries' chemical warfare capabilities may go undetected. Data volumes and analysis needs will overwhelm analyst capabilities threatening our information dominance strategy. Course of action decision support for Desert Storm size engagements will not be feasible.

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US Computer Industry Not Producing Next High End Generation to Meet National Security Needs

US computer industry unable or unwilling to invest their own resources to meet high end national security needs

- Insufficient ROI
- Opportunity Cost
- Uncertain Market Future

14

We cannot expect industry to invest their own resources to meet national security needs without a predictable and profitable customer base. Industry needs include stable and predictable procurements, at a level which encourages R&D investment, pricing structures which cover one-time costs of engineering and development and long-term research to pioneer architectures and technologies.

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National Security Threats

- US technology and products may not be available to meet high end National Security needs.
- A potential collapse by withdrawal from market because of insufficient return on investment would lead to dependencies and unpredictable lead times for procurement
- Possible denial of high end systems to US Defense Programs (e.g. Nuclear)
- Expensive special purpose development systems would require years for development.
- Loss of technology base for special purpose development systems with very large costs for replacement
- Long-term technology loss in critical weapons leadership

15

US vendor issues in the high end of computing market pose a number of threats to national security. In addition, it can not be presumed that the current investment strategy of the Japanese companies will be continued if the overall market remains relatively small and flat. Therefore the threat to national security caused by the lack of investment and small number of viable competitors is significant..

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Conclusions and Recommendations

- US has critical national security needs for high end technology and technology leadership that are not being met
- Without additional government action, US high end technology will not be available to meet national security leading edge needs
- These concerns require a proactive approach by the defense and national security community to determine an appropriate government response
- The community should implement measures to maintain technology leadership by establishing a joint, high end, national security partnership with industry

16

National security interests require a strong, proactive approach to high end computing. The IPT believes that the national security needs require government to establish strong partnership with industry. This approach should address procurement policy, the costs of prototypes and non-recurring engineering for advanced high end systems, software development, and long-term research. The IPT believes that near-term action is required to reverse the eroding US technology position and without this action risks to national security will increase significantly.